Geotechnical Report

for

Massachusetts Department of Transportation – Highway Division

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Project File No. 608929

Complete Bridge Replacement Project

for

Bridge No. W-38-003 (C99)

Butters Row over MBTA/Pan Am Railroad

Wilmington, Massachusetts

Revision Date: 5/22/2023

Prepared for:
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1.0 EXECUTIVE SUMMARY

Based on the 2021 boring exploration results, the proposed single-span W18 steel rolled beam composite with concrete deck superstructure can be supported by reinforced concrete abutments on three rows of micropiles. The bottom of pile cap is at Elev. 77.0 and Elev. 76.5 for west abutment and east abutment, respectively. Each abutment micropile is socketed 8 feet into bedrock comprising of 7 feet bonded length and 1 foot plunge length. The tip of the micropile is estimated at Elev. 61.0 and Elev. 62.2 for west abutment and east abutment, respectively, and should be adjusted according to the actual top of bedrock elevation at each micropile location.

The proposed wingwalls are also supported on three rows of micropiles. Wingwall Type 1 has the same bottom of pile cap elevation and bedrock socket length as those of the abutment. Wingwall Types 2 and 2A are supported on 2 rows of piles with the first row battered and the bottom of pile cap elevation varies. Each wingwall micropile is socketed 6.5 feet into bedrock comprising of 5.5 feet bonded length and 1 foot plunge length. The tip of the micropile elevation varies and should be adjusted according to the actual top of bedrock elevation at each micropile location.

The nominal and the factored micropile resistance values for bridge abutment and wingwall foundations are included in Section 6.0, 'Summary' of this report.

This report was prepared mainly for the bridge structure. Geotechnical information for the project retaining walls is included in a separate supplemental report.

2.0 INTRODUCTION

2.1 Scope of Report

The purpose of this report is to evaluate the substructure foundation types for the proposed superstructure system based on the 2021 boring exploration results, make recommendations for the proposed foundation system, develop engineering design values, and identify possible construction issues. The design values are prepared in AASHTO LRFD format to be compatible with the current bridge design approach.

2.2 Existing Bridge & Foundation

Bridge No. W-38-003 (C99) is located on Butters Row over MBTA/Pan Am Railroad in the Town of Wilmington, as illustrated in Figure 1, 'Project Location Plan'.

The existing bridge is a three-span timber beam superstructure with deck comprised of transverse wood planks. The overall length of the structure is 66'-5" ± with three (3) spans from west to east measuring at 20'-10" ±, 26'-4" ±, and 19'3" ± long, respectively. The structure carries one (1) travel lane with a curb-to-curb width of 13'-6" ± for 2-way traffic. The bridge has skew angles of 12°11'05" at Pier 2 and 11°11'05" at Pier 1.

The existing substructures consist of unreinforced concrete abutments, concrete and timber wingwalls, and timber piers. All substructures are supported by shallow spread footings.

According to the DOT Structures Inspection Field Report, dated June 18, 2018, the Bridge Deck, Superstructure, and Substructure were rated at 7 (Good), 6 (satisfactory), and 5 (fair), respectively.

The existing bridge will be closed during construction.

2.3 Proposed Bridge

The design concept of the proposed single span bridge structure can be found on the Bridge Plan Submittal prepared by Green International Affiliates, Inc. (Green), who is the Prime Design Engineer for the project. Lamson Engineering Corporation (LEC) is a sub-consultant to Green, responsible for the geotechnical design of the project.

The proposed bridge consists of seven (7) W18 steel rolled beams composite with an 8" thick reinforced concrete cast-in-place deck slab and a 3" overlay wearing surface. The single skewed span length of the bridge is 40'-6" from centerline of bearing to centerline of bearing. The overall width of the bridge deck is 45'-9", including two (2) 5'-6" wide sidewalks. The skew angle is set at 11°-21'-34", similar to the existing bridge skew angle.

The proposed bridge will be designed according to AASHTO LRFD requirements with vehicular live loading of HL-93. The geotechnical design bearing values to be provided will be nominal geotechnical resistance and factored geotechnical resistance values.

2.4 Proposed Southeast, Southwest, Northeast, and Northwest Wingwalls

The design concept of the proposed wingwalls can also be found on the Bridge Plan Submittal prepared by Green International Affiliates, Inc. Retaining walls at the southeast (SE), southwest (SW), northeast (NE), and northwest (NW) approaches were added to the scope during the preparation of the revised Plans based on the coordination with MassDOT to reduce the ROW and wetland impacts. Additional boring information for the new retaining walls is included in a separate supplemental report.

The new wingwalls are located from approximately Stations 53+80.18 RT. to 54+11.34 RT. at SW Wingwall, Stations 54+57.45 RT. to 54+90.18 RT. at SE wingwall, Stations 53+86.54 LT. to 54+20.53 LT. at NW wingwall, and Stations 54+97.66 LT to 54+66.64 LT. at NE wingwall along Butters Row.

According to the wall height, there are also Types 1, 2, and 2A walls. SE and SW Wingwalls have Wall Types 1 and 2, NE Wingwall has Wall Types 1 and 2A, and NW Wingwall has Wall Types 1 and 2.

2.5 References

The following references were used in the preparation of this report:

- MassDOT LRFD Bridge Manual, 2020 Revision.
- AASHTO LRFD Bridge Design Specifications, 2020, 9th Edition
- AASHTO Guide Specifications for LRFD Seismic Bridge Design, 2011, 2nd Edition with 2012, 2014, and 2015 Interim Revisions.
- Surficial geology of the Wilmington quadrangle, Massachusetts by R.O. Castle, 1959

- Bedrock Geologic Map of the Wilmington Quadrangle, Massachusetts by R.O. Castle, J.C. Hepburn, and J.P. Kopera, 2005

3.0 SUBSURFACE CONDITIONS

3.1 Local Geology

Based on the Surficial geology of the Wilmington quadrangle, Massachusetts map, the surficial geologic deposits at the site consist of thin layers of swamp deposits, mainly peat, commonly overlying undifferentiated sand and gravel deposits, with various kame deposits of poorly sorted pebble to boulder gravel and sand. Based on the Bedrock Geologic Map of the Wilmington quadrangle, Massachusetts and the recovered rock cores from the 2021 boring exploration program, the bedrock consists of medium-to coarse grained, very light-to dark-gray Diorite and Granite Gneiss.

3.2 2021 Subsurface Exploration Program

A subsurface exploration program consisting of five (5) test borings for the proposed bridge structure is shown on Figure 2, 'As-Drilled 2021Boring Location Plan'.

Borings BB-1, BB-3 and BB-5 were conducted for the West Abutment and Wingwalls. Borings BB-2/2A/2B and BB-4 were conducted for the East Abutment and Wingwalls.

The explorations were performed between January 11, 2021 to January 15, 2021 by New England Boring Contractors of Derry, New Hampshire. The monitoring of the boring explorations was performed by Lamson Engineering Corporation. Materials recorded on the boring logs were visually inspected on site by the engineer from Lamson Engineering, who is also involved in the preparation of this report.

The soil samples were taken using a 2" outside diameter split spoon sampler driven into the soil by a 140-pound hammer falling 30". Blows per 6" were recorded. The classification and the description of the sample materials at the site were included on the boring logs, and are also included on the soil profile in Figures 3 to 5 of this report.

Based on the 2021 boring results, the predominant materials at the site are sand and gravel, with minor organic materials and occasional boulders and cobbles.

Loose, fine sand materials were encountered from Elev. 77.7 to Elev. 73.2 and from Elev. 80.7 to Elev. 73.2 at Borings BB-3 and BB-5, respectively. Approximately 1.0' of peat materials were encountered at a depth of 13' (Approximately Elev. 88.5) at Boring BB-2B, located east of Existing East Abutment. Approximately 1.3' of wood materials were encountered at a depth of 8.2' (Approximately Elev. 81.0) at Boring BB-3, located northwest of Existing West Abutment.

3.3 Organic Materials Information

Based on the boring logs, information on organic materials can be obtained as follows:

Table 3.3: Organic Materials Information

Boring No.	Ground Elevation (Feet)	Organic Materials			Remark
		Materials	Depth from Existing Ground (Elev.)	Layer Thickness (Feet)	
BB-2B	101.5	Organics	13.0’ to 14.0’ (Elev. 88.5 to Elev. 87.5)	1.0’	East Abutment
BB-3	87.2	Organic Silt	0’ to 8.2’ (Elev. 87.2 to Elev. 79.0)	8.2’	Northwest Wingwall
		Wood	8.2’ to 9.5’ (Elev. 79.0 to Elev. 77.7)	1.3’	

Organic materials were encountered from Elev. 77.7 to Elev. 88.5.

3.4 Cobbles / Boulders Information

Pockets of cobbles / boulders materials were encountered during the 2021 subsurface exploration.

Table 3.4: Cobbles / Boulders Information

Boring No.	Ground Elevation (Feet)	Top of Cobble / Boulder Depth/ (Elev.)	Bot. of Cobble / Boulder Depth/ (Elev.)	Layer Thickness (Feet)	Remark
BB-1	101.5	9.2’ (92.3)	15.3’ (86.2)	6.1	West Abutment
BB-2B	101.5	21.3’ (80.2)	24.8’ (76.7)	3.5	East Abutment
		28.8’ (72.7)	29.4’ (72.1)	0.6	
BB-4	100.3	21.3’ (79.0)	21.8’ (78.5)	0.5	Northeast Wingwall
		24.5’ (75.8)	26.0’ (74.3)	1.5	

3.5 Bedrock Information

Bedrock was encountered during the 2021 boring exploration at an average of Elev. 68.8.

Table 3.5: Bedrock Information

Boring No.	Ground Elevation (Feet)	Depth from Ground Surface	Top of Bedrock Elev.	RQD	Unconfined Compressive Strength, psi	Bedrock Type
BB-1	Elev. 101.5	32’-6”	Elev. 69.0	C1: 100% C2: 90%	-	Diorite
BB-2B	Elev. 101.5	31’-3”	Elev. 70.3	C1: 83% C2: 83%	23,836 (Note 1)	Grano Diorite / Granite Gneiss
BB-3	Elev. 87.2	20’-3”	Elev. 67.0	C1: 83% C2: 88%	-	Granite Gneiss
		Average	Elev. 68.8			

Notes:
1. The unconfined compressive strength is obtained from laboratory testing for Boring BB-2B bedrock core sample from Elev. 69.5 to Elev. 68.5.
2. RQD = Rock Quality Designation, C1= Core Run No. 1

3.6 2021 Groundwater Information

Based on the boring logs, groundwater information can be obtained. However, the obtained groundwater information from the washed boring operation is presented for preliminary reference only.

Table 3.6: 2021 Groundwater Information Measured after Washed Boring Operation

Boring No.	Ground Elev. (Feet)	Groundwater Depth (Feet)	Estimated Groundwater Elev. (Feet)	Remark
BB-1	Elev. 101.5	12.6’	Elev. 89.9	West Abutment
BB-2B	Elev. 101.5	15’-0”	Elev. 86.5	East Abutment
BB-3	Elev. 87.2	4’-0”	Elev. 83.2	West Abutment & Northwest Wingwall
BB-4	Elev. 100.3	14’-0”	Elev. 86.3	East Abutment & Northeast Wingwall
BB-5	Elev. 88.7	5’-6”	Elev. 83.2	Northwest Wingwall

3.7 Seismic Design Category Evaluation

Based on the 2020 Revision M*assDOT* Bridge Manual 3.4.1, all seismic analysis and design of bridges shall be performed in accordance with the 'AASHTO Guide Specifications for LRFD Seismic Bridge Design'. Based on the 2011 Guide Specifications with 2012, 2014, and 2015 Interim Revisions Table 3.4.2.1-1 (same as AASHTO Table 3.10.3.1-1) for site soil type and profile, the site class is C (F_{pga} = 1.2, F_a = 1.2, F_v = 1.7).

This structure is considered a non-critical/ non-essential convential bridge, and a 1,000-year return period is used. With these results and Appendix 3, 'USGS Seismic Hazard Map for the 1,000-year return period', the following can be obtained:

Acceleration Coefficient (A_s) = 0.096g
Design Spectral Acceleration Coefficient at 0.2-sec Period (S_{DS}) = 0.192g
Design Spectral Acceleration Coefficient at 1.0-sec Period (S_{D1}) = 0.068g

Since S_{D1} is less than 0.15g, the Seismic Design Category (SDC) is A. This is based on Guide Specifications Table 3.5-1 (same as AASHTO Table 4.7.4.3.1-1).

3.8 Liquefaction Potential

A liquefaction assessment is not required for structures in Seismic Design Category (SDC) A. Furthermore, the proposed bridge structure and wingwall are supported with micropile socketed into bedrock. This type of foundation helps to maintain the integrity of the structure in a seismic event.

4.0 FOUNDATION RECOMMENDATIONS

4.1 Proposed Bridge Abutment Foundation

Shallow Foundation
Due to the presence of loose sand and peat materials below the proposed bottom of footing, a shallow spread footing foundation type is not recommended for this bridge project.

Deep Foundation
Deep foundation, such as micropile type, is suitable to support the proposed loads at both abutments and wingwalls. Micropile can carry loads through soil materials to the bedrock below. Micropiles can also drill through organic materials and obstructions like cobbles and boulders. Based on the information shown on the boring logs, the proposed single-span superstructure can be supported by micropiles socketed into bedrock for both abutments and wingwalls.

Other type of deep foundation, such as, steel H-pile is not preferred to be used for this site due to large boulders encountered at multiple borings during the boring exploration.

The proposed superstructure can be supported by reinforced concrete abutments on three rows of micropiles. The bottom of pile cap is at Elev. 77.0 and Elev. 76.5 for West Abutment and East Abutment, respectively. Each micropile is socketed 8 feet into bedrock comprising of 7 feet

bonded length and 1 foot plunge length. The tip of the micropile is estimated at Elev. 61.0 and Elev. 62.2 for West Abutment and East Abutment, respectively. These elevations should be adjusted according to the actual top of bedrock found at each micropile location during construction. In installation of permanent steel casing, no threaded casing joints shall be located within 15 feet of the pile cap.

The strength and material properties, nominal and factored micropile resistance values are included in Section 6.0, 'Summary' of this report.

Settlement: Since the micropile is socked into bedrock, settlement is negligible.

Spacing: The minimum pile spacing should not be less than 3'-6", and the maximum pile spacing shall not be more than 10'-0".

4.2 Proposed Abutment Design Parameters

The following parameters are recommended for design at the back of the micropile abutment and wingwall:

Moist Unit Weight of Soil = 125 pcf (behind wall)
Soil Friction Angle = 37°
Active Lateral Earth Pressure Coefficient = 0.25
At-Rest Lateral Soil Pressure Coefficient = 0.40

Lateral earth pressure values used for design shall be in conformance with *MassDOT* BM 3.1.6.

4.3 Wingwalls

Based on Bridge Manual Section 3.3.2 with the proposed wall height being greater than 14', cantilevered type wingwall is recommended.

Like the proposed bridge abutment foundation, proposed wingwalls can be supported by concrete abutments on three rows of micropiles. For Wingwall Type 1, the bottom of pile cap elevation, pile bedrock socketed length, and bonded length will be the same as those for the abutment. For Wingwall Types 2 and 2A, the bottom of pile cap elevation varies.

For Wingwall Types 2 and 2A, each micropile is socketed 6.5 feet into bedrock comprising of 5.5 feet bonded length and 1 foot plunge length. The tip of the micropile is estimated at Elev. 60.5. This elevation should be adjusted according to the actual top of bedrock found at each micropile location during construction.

The strength and material properties, nominal and factored micropile resistance values are included in Section 6.0, 'Summary' of this report.

Settlement: Since the micropile is socked into bedrock, settlement is negligible.

4.4 Proposed Wingwall Design Parameters

The following parameters are recommended for design at the back of the micropile wingwall:

Moist Unit Weight of Soil = 125 pcf (behind wall)
Soil Friction Angle = 37°
Active Lateral Earth Pressure Coefficient = 0.25
At-Rest Lateral Soil Pressure Coefficient = 0.40
Soil Friction Angle = 30° (below footing)

Lateral earth pressure values used for design shall be in conformance with *MassDOT* BM 3.1.6.

The proposed concrete cantilevered wingwalls are to be designed according to the AASHTO LRFD and MassDOT LRFD Bridge manual requirements.

4" diameter weep holes should be used behind the proposed wingwalls at 10' maximum on center to minimize hydrostatic pressure on the back of the walls.

4.5 Retaining Walls

There are retaining walls for this project. A separate supplemental geotechnical report is prepared for the wall foundation with additional boring information.

4.6 Load Test (for Bridge Structure)

Based on AASHTO 10.9.3.5.4, we recommend a 'Micropile Verification Load Test' (Item 948.60) be performed on a sacrificial pile prior to ordering of production piles. The minimum number of sacrificial pile should be one for west abutment. The sacrificial pile shall be within 10 feet of the footprint of a substructure unit, but at least 5 feet from any production pile as selected by the Contractor and accepted by the Engineer.

We also recommend 'Micropile Proof Load Test' (Item 948.61) be performed on six (6) production piles, one for each of the abutment, NE, NW, SE & SW wingwalls. According to AASHTO 9th Edition, Section 10.9.3.5.4, proof load tests are 1 pile for each substructure unit or 5% of the total piles. Since the total micropiles are 78 piles supporting proposed abutments and wingwalls, the recommended proof load tests are six (6) for bridge abutments and wingwalls.

The rebar size used should be greater than the Factored Design Load (FDL) for 'Micropile Proof Load Test' and 1.5 times of Factored Design Load for 'Micropile Verification Load Test'. The contractor may need to increase the size or grade of the center reinforcement steel bar for the verification tests.

Contractor should prepare and submit load testing plan for Engineer's review and approval.

Table 4.6: Load Test

Location of Testing Pile	Pile Type	Micropile Verification Load Test (Item 948.60)	Micropile Proof Load Test (Item 948.61)	Remark
West Abutment and Wingwalls	Sacrificial Pile	1	-	Prior to ordering of production piles
	Production Pile	-	3	One minimum of each of pile for West Abutment and NW and SW wingwalls
East Abutment and Wingwalls	Sacrificial Pile	-	-	-
	Production Pile	-	3	One minimum of each of pile for East Abutment and NE and SE wingwalls
	Total:	1	6	

4.7 Soil Parameters

Based on the information in the boring logs, the following soil parameters are recommended:

Table 4.7: Recommended Soil Parameters

Structural Component	Soil Layer	Materials	Soil Unit Weight, γ	Soil Friction Angle, ϕ_f	Boring #
Abutments	Soil above bottom of footing	Gravel Borrow for Backfilling Structures & Pipes	125 pcf	37°	BB-1 & BB-2B
	Soil below bottom of footing	Loose Sand	115 pcf	30°	
		Medium Dense Sand	120 pcf	32°	
Wingwall	Soil below bottom of footing	Loose Sand	115 pcf	30°	BB-3 & BB-5
		Medium Dense Sand	120 pcf	32°	
		Dense Sand	125 pcf	35°	

Other applicable parameters are also included in the attached calculations.

5.0 CONSTRUCTION CONSIDERATIONS

5.1 Water Control

Since the measured water levels encountered during the 2021 boring operation were above the bottom of the pile caps and footing, water control is expected to be needed during the proposed foundation construction.

Water levels recorded on the boring logs were not accurate due to the washed boring operation. They do not represent the water level that will be encountered during the future construction excavation operation.

The following factors should be taken into consideration for the recorded water levels:

- Groundwater levels obtained from the boring exploration operation are generally unreliable and are provided for reference only.
- Groundwater levels fluctuate over time due to seasonal changes.

5.2 Permanent Earth Support System

Permanent earth support system will be required to support railroad loading for the project. It shall be designed in accordance with the MassDOT Standard Specifications Section 950, 'Sheeting'. The earth support system should be designed for the approved MBTA railroad loading. Due to the boulder materials at the site, predrilling may be needed prior to the permanent earth support installation. Due to high bedrock level at the site, bracing may be needed during proposed foundation construction prior to backfilling.

For temporary earth support system, it should be designed, in addition to the earth loading, for the Contractor's intended construction equipment intended to be used during excavation.

5.3 Utilities

There is an underground 30" diameter sewer main near the existing bridge foundation. There are also overhead electrical, cable, and telephone lines parallel to the bridge along the south fascia. The contractor should ensure that all existing utilities are relocated prior to the proposed foundation construction.

There is a 30" diameter drain line going through the northwest retaining wall. The Contractor should protect this line according to the details shown on the construction plan.

5.4 Obstructions

Underground/overhead utilities, boulders, and unknown previous construction materials are potential obstruction materials that may be encountered at the site during construction. Contractor should prepare for these potential obstruction materials during the proposed foundation excavation.

5.5 Subgrade Preparation

Excavation during the bridge foundation construction should be in accordance with MassDOT Standard Specifications Section 140, 'Excavation for Structures'. Backfilling during the bridge foundation construction should be in accordance with MassDOT Standard Specifications Section 150, 'Embankment'.

5.6 Construction monitoring

Due to the proximity of the construction areas near the active railroad tracks, we recommend that monitoring of the top of rail be performed via survey to provide for early warning on the effect of the construction on the track to ensure that the track performance will not be affected by the proposed substructure construction. We also recommend that prior to the start of construction, a baseline or an initial condition survey should be performed. Thereafter, the monitoring frequencies should be conducted according to the needs and types of on-going activities.

6.0 SUMMARY

6.1 Summary of Proposed Micropile Resistance – Abutment and Wingwall Type 1

Abutments (3 rows of micropiles for each abutment)
Wingwall Type 1 (3 rows with front row of micropiles being battered at 4V:1H)

Steel Casing: 10.75" O.D. x 0.595", API 52 (F_y = 52 ksi), Wall Thickness = 0.595 in, Area = 18.98 in^2
Consider 1/16" Potential Corrosion, Reduced Casing Thickness = 0.5325 in, Reduced Area = 16.9 in^2

Steel Reinforcing Bar: #14, Threaded, Grade 60
Cement Grout: Neat Mix of Portland Cement (Type I or II), M85 (ASTM C150), f'_c = 5,000 psi

Rock Socket Diameter = 9.56 in

Estimated Bonded Length into Rock (Grout into Rock)	7 ft
Plunge Length (Casing into Rock)	1 ft
Nominal Geotechnical Pile Resistance per Pile	378 kips
Side Resistance Factor, φ_{stat}	0.55
Factored Geotechnical Pile Resistance per Pile	208 kips
Nominal Uplift Resistance per Pile	189 kips
Resistance Factor, φ_{up}	0.55
Factored Uplift Resistance per Pile	104 kips

Nominal Structural Pile Resistance per Pile	= 1,097 kips	(Portion of Cased Length) – Note 1
Nominal Structural Pile Resistance per Pile	= 366 kips	(Portion of Uncased Length) – Note 1
Compression Resistance Factor, φ_C	= 0.75	
Factored Structural Pile Resistance per Pile	= 823 kips	(Portion of Cased Length)
Factored Structural Pile Resistance per Pile	= 274 kips	(Portion of Uncased Length)
Nominal Tension Resistance	= 995 kips	(Portion of Cased Length)
Nominal Tension Resistance	= 135 kips	(Portion of Uncased Length)
Tension Resistance Factor, φ_T	= 0.80	
Factored Tension Resistance	= 796 kips	(Portion of Cased Length)
Factored Tension Resistance	= 108 kips	(Portion of Uncased Length)

Note 1: The Portion of Micropile is cased through 1 foot below top of bedrock, whereas the uncased portion of Micropile is from 1 foot below top of bedrock.

6.2 Summary of Proposed Micropile Resistance – Wingwall Types 2 and 2A

Wingwall Types 2 & 2A (3 rows with front row of micropiles being battered at 4V:1H)

Steel Casing: 10.75" O.D. x 0.595", API 52 (F_y = 52 ksi), Wall Thickness = 0.595 in, Area = 18.98 in^2
Consider 1/16" Potential Corrosion, Reduced Casing Thickness = 0.5325 in, Reduced Area = 16.9 in^2

Steel Reinforcing Bar: #14, Threaded, Grade 60
Cement Grout: Neat Mix of Portland Cement (Type I or II), M85 (ASTM C150), f'_c = 5,000 psi

Rock Socket Diameter = 9.56 in

Estimated Bonded Length into Rock (Grout into Rock)	5.5 ft
Plunge Length (Casing into Rock)	1 ft
Nominal Geotechnical Pile Resistance per Pile	297 kips
Side Resistance Factor, φ_{stat}	0.55
Tip Resistance Factor on Rock, φ_{stat}	0.50
Factored Geotechnical Pile Resistance per Pile	164 kips
Nominal Uplift Resistance per Pile	149 kips
Resistance Factor, φ_{up}	0.55
Factored Uplift Resistance per Pile	82 kips

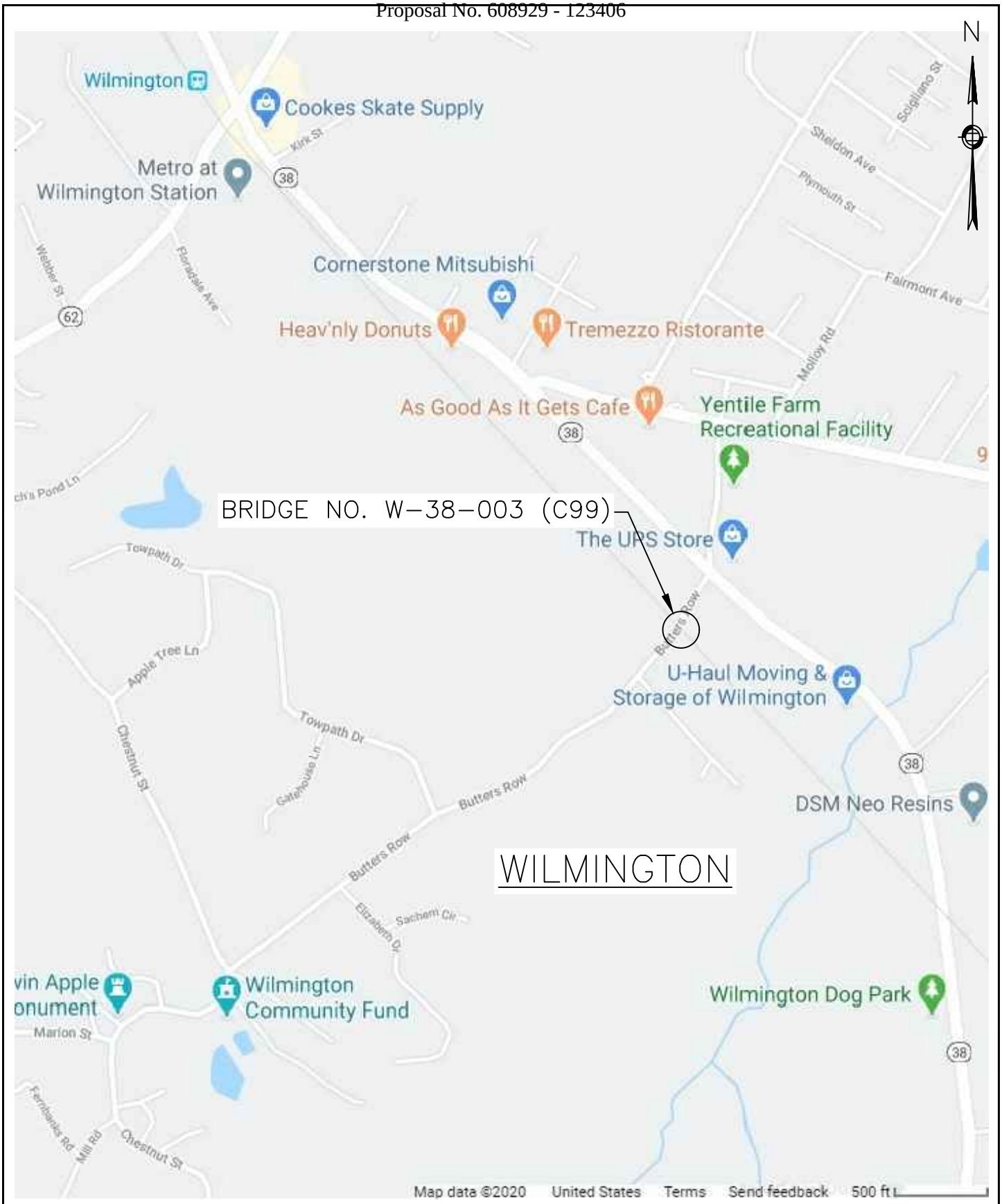
Nominal Structural Pile Resistance per Pile	= 1,097 kips	(Portion of Cased Length) – Note 1
Nominal Structural Pile Resistance per Pile	= 366 kips	(Portion of Uncased Length) – Note 1
Compression Resistance Factor, φ_C	= 0.75	
Factored Structural Pile Resistance per Pile	= 823 kips	(Portion of Cased Length)
Factored Structural Pile Resistance per Pile	= 274 kips	(Portion of Uncased Length)
Nominal Tension Resistance	= 995 kips	(Portion of Cased Length)
Nominal Tension Resistance	= 135 kips	(Portion of Uncased Length)
Tension Resistance Factor, φ_T	= 0.80	
Factored Tension Resistance	= 796 kips	(Portion of Cased Length)
Factored Tension Resistance	= 108 kips	(Portion of Uncased Length)

6.3 Summary of Micropile Shear Resistance at 1” Displacement

Type	Abutment	Wingwall Type 1	Wingwall Types 2 & 2A
10.75” x 0.595” Micropile	52 kips	37 kips	28 kips

Note 1: The Portion of Micropile is cased through 1 foot below top of bedrock, whereas the uncased portion of Micropile is from 1 foot below top of bedrock.

FIGURES



massDOT Highway

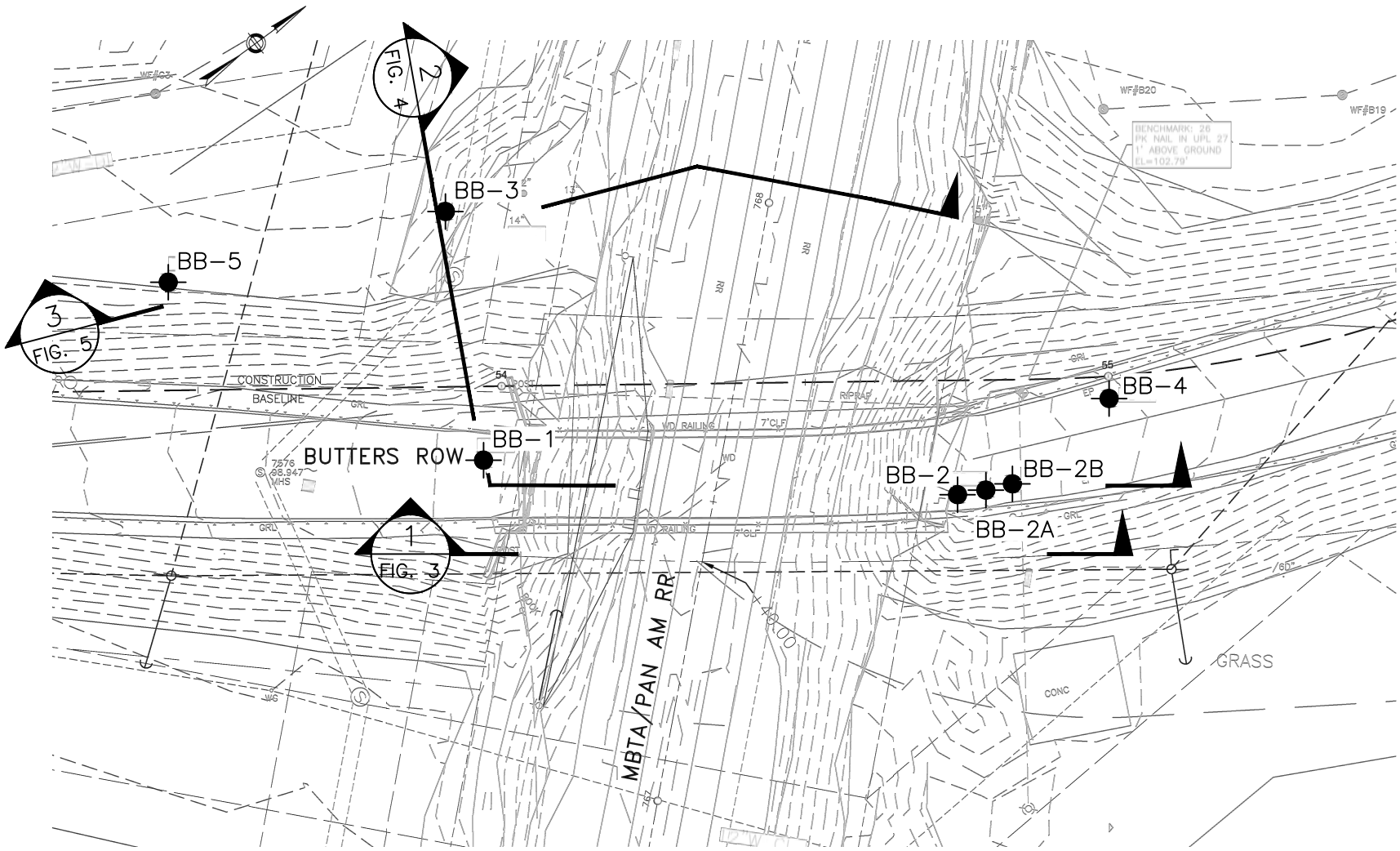
GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PROJECT LOCATION PLAN
AS NOTED

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 1

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS



AS-DRILLED 2021 BORING LOCATION PLAN

NOT TO SCALE

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 2

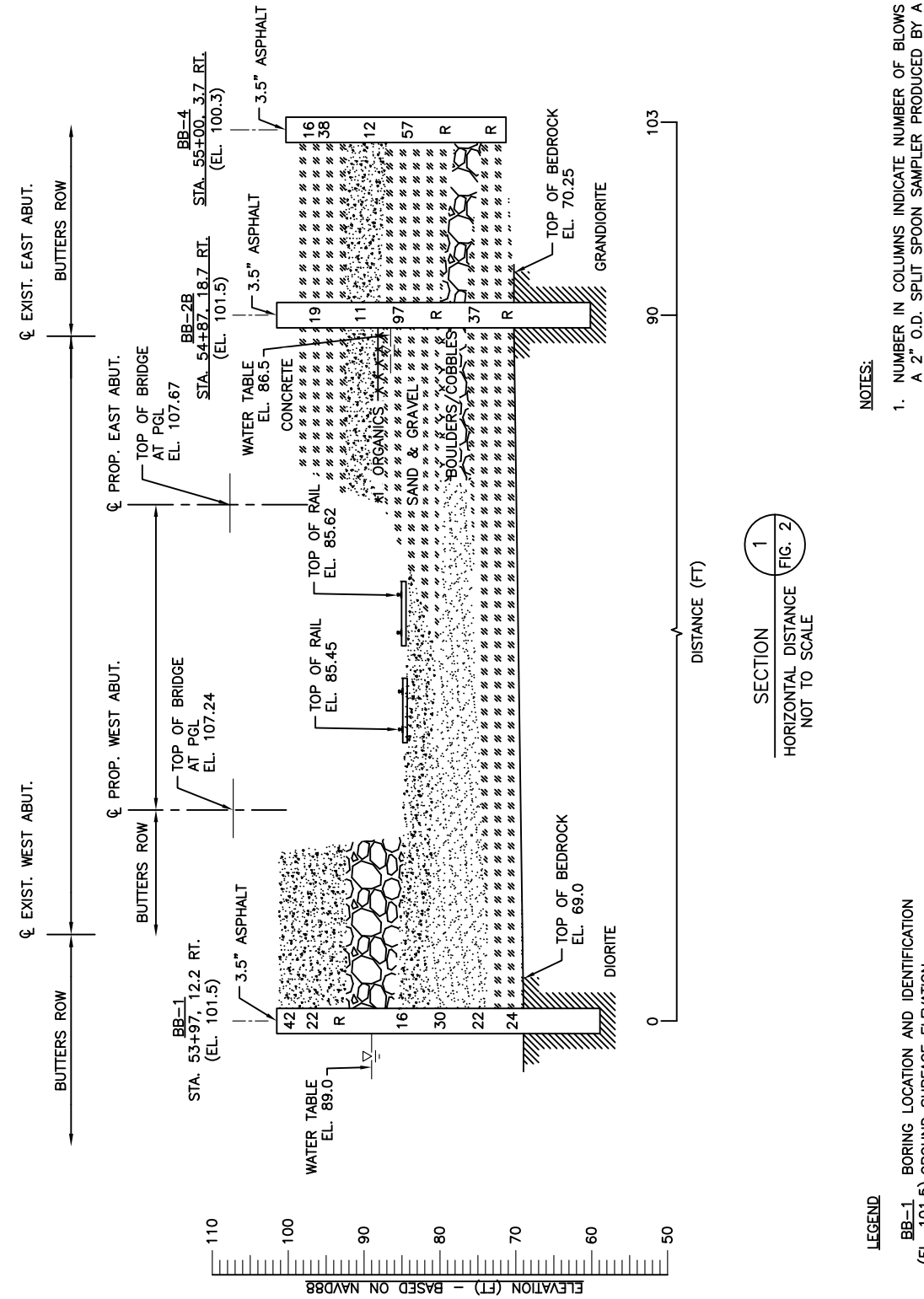
AS-DRILLED 2021 BORING LOCATIONS (FEET)			
BORING NO.	NORTHING	EASTING	SURF. EL.
BB-1	3,021,503	746,507	101.5
BB-2	3,021,507	746,558	102.0
*BB-2A	3,021,511	746,558	101.7
*BB-2B	3,021,516	746,558	101.5
*BB-3	3,021,527	746,470	87.2
BB-4	3,021,592	746,560	100.3
BB-5	3,021,479	746,453	88.7

NOTE: * COORDINATES AND ELEVATIONS ARE ESTIMATED.

LEGEND:

BB-X — AS-DRILLED 2021 BORING

NOTE: FOR RETAINING WALL BORINGS, SEE SUPPLEMENTAL GEOTECHNICAL REPORT.



NOTES:

1. NUMBER IN COLUMNS INDICATE NUMBER OF BLOWS PER 12" ON A 2" O.D. SPLIT SPOON SAMPLER PRODUCED BY A 30 INCH FALL OF A 140 LB HAMMER.
2. THE ELEVATIONS SHOWN ARE BASED ON THE 1988 NAVD DATUM.

GENERAL NOTE:

SOIL MATERIALS AND TOP OF BEDROCK ELEVATION SHOWN BETWEEN BORINGS ARE PRELIMINARY BASED ON CONDUCTED BORINGS INFORMATION, AND THEY ARE NOT GUARANTEED TO BE THE MATERIALS OR TOP OF BEDROCK TO BE ENCOUNTERED AT OTHER LOCATIONS OF THE SITE.

LEGEND

BB-1 (EL. 101.5) BORING LOCATION AND IDENTIFICATION
GROUND SURFACE ELEVATION
42 N VALUE (BLOWS/12")
WATER TABLE
R REFUSAL (N>120)
BEDROCK

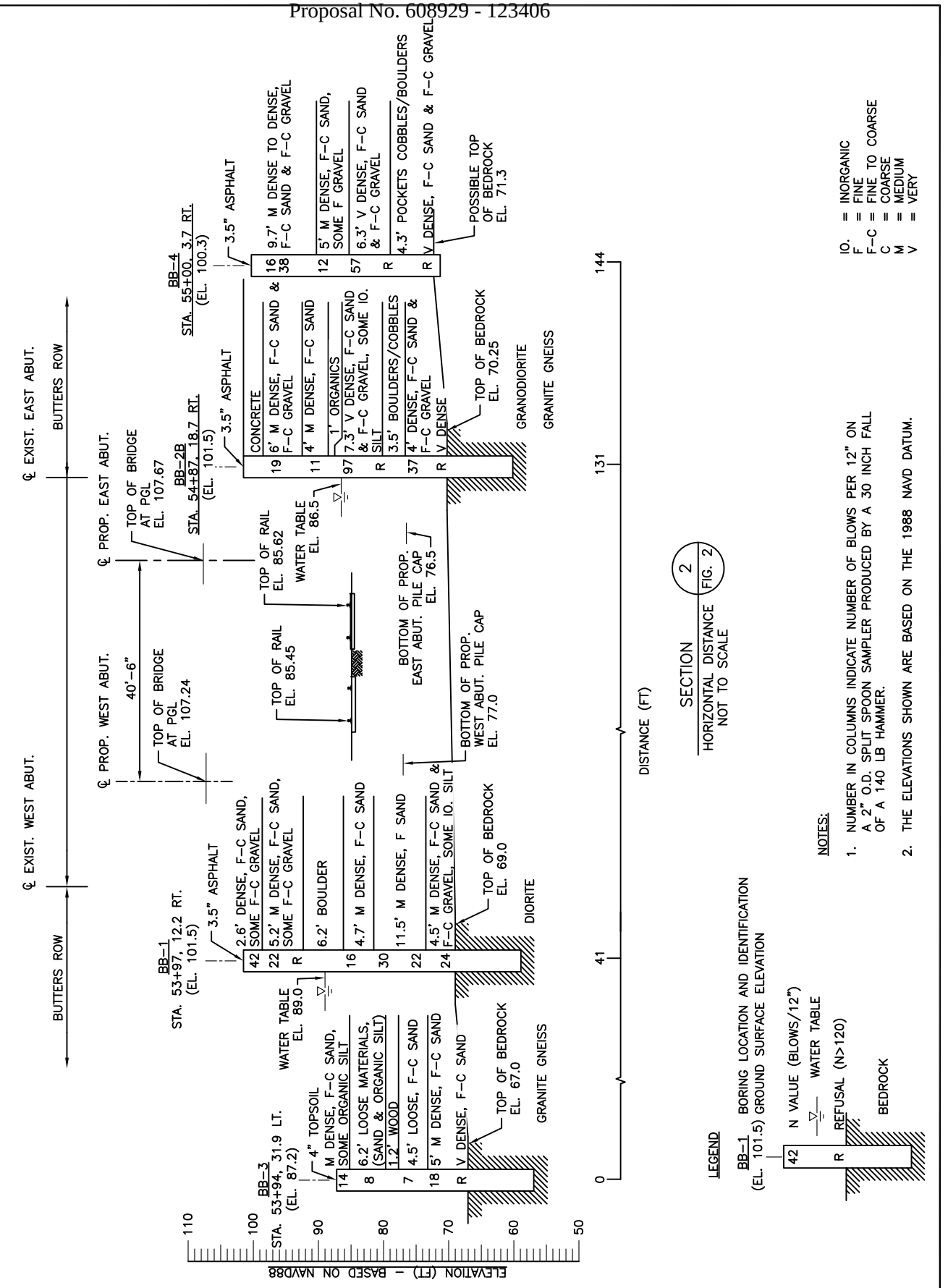
SAND, SOME GRAVEL
BOULDERS & COBBLES
SAND
SAND & GRAVEL
PEAT

massDOT
GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

SOIL PROFILE – PICTORIAL VIEW
VERTICAL SCALE: 3/64" = 1'-0"

PREPARED BY
LAMSON ENGINEERING CORP.
NEWTON, MASS.

Fig. 3



massDOT
a Highway

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

SOIL PROFILE – DESCRIPTIVE VIEW (1/2)
VERTICAL SCALE: 3/64" = 1'-0"

PREPARED BY
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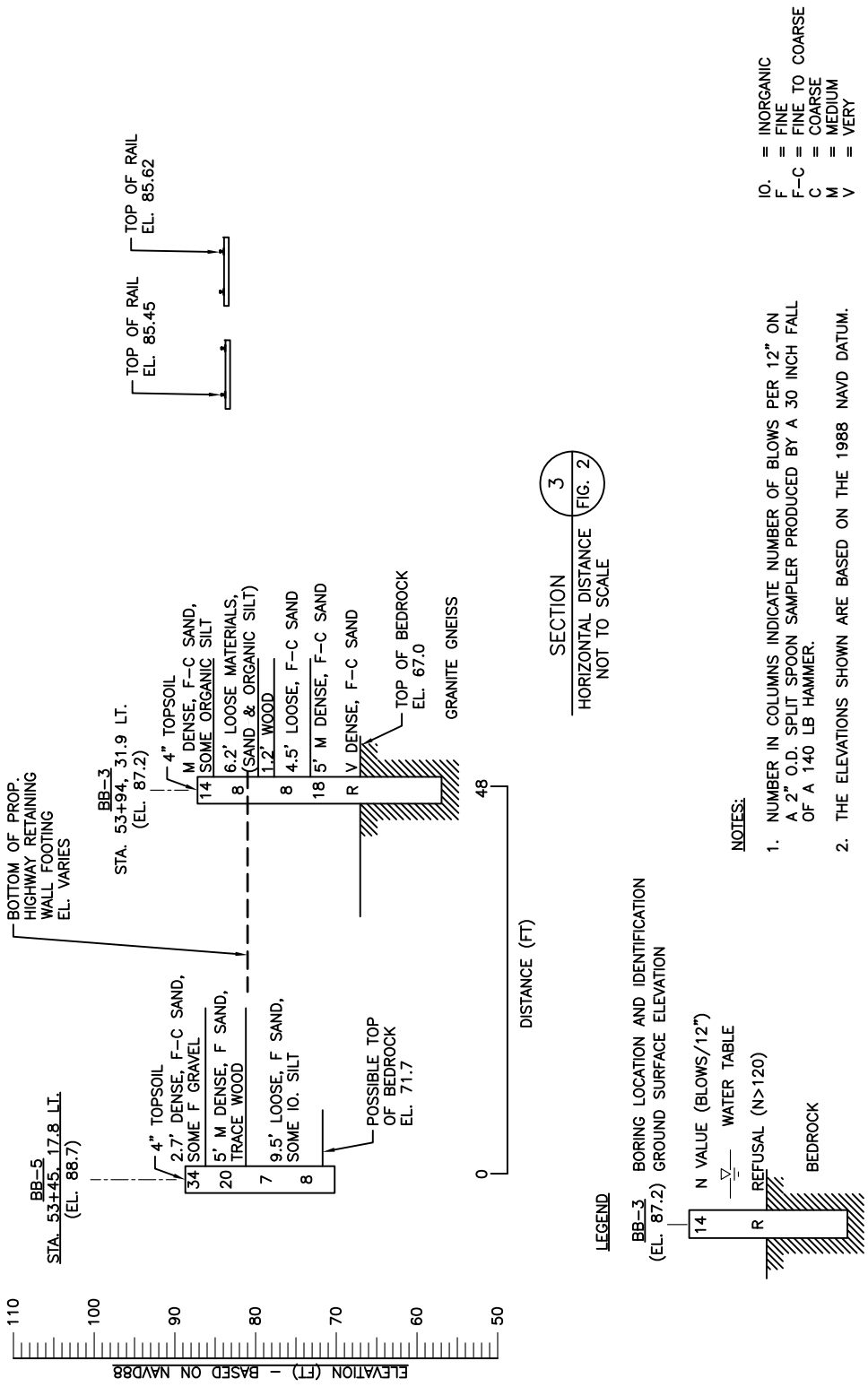
NEWTON, MASS.

Fig. 4



massDOT
Highway

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

SOIL PROFILE – DESCRIPTIVE VIEW (2/2)

VERTICAL SCALE: 3/64" = 1'-0"

PREPARED BY
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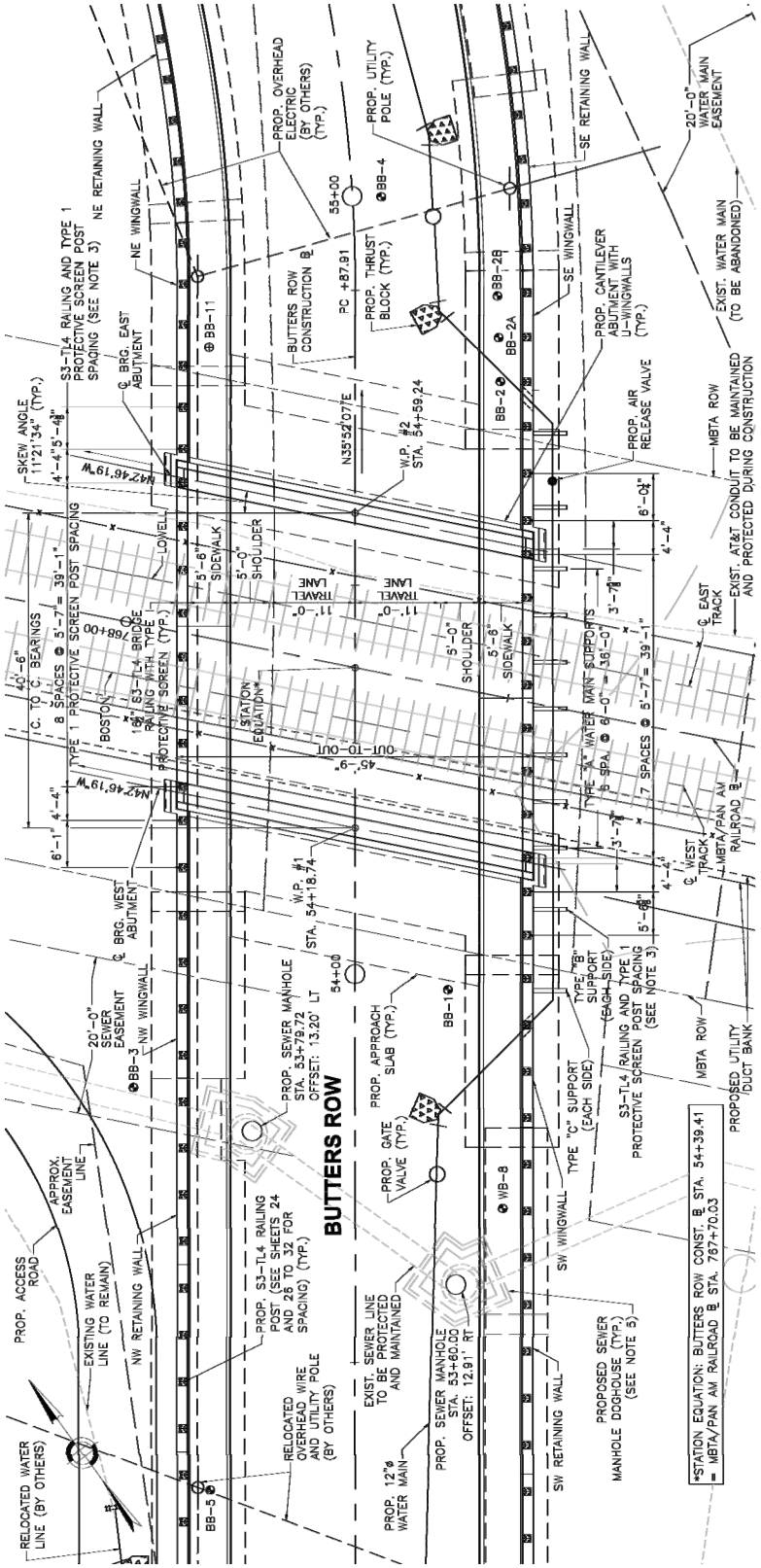
NEWTON, MASS.

Fig. 5



PROPOSED BRIDGE PLAN

massDOT a Highway

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PROPOSED BRIDGE PLAN
SCALE: NOT TO SCALE

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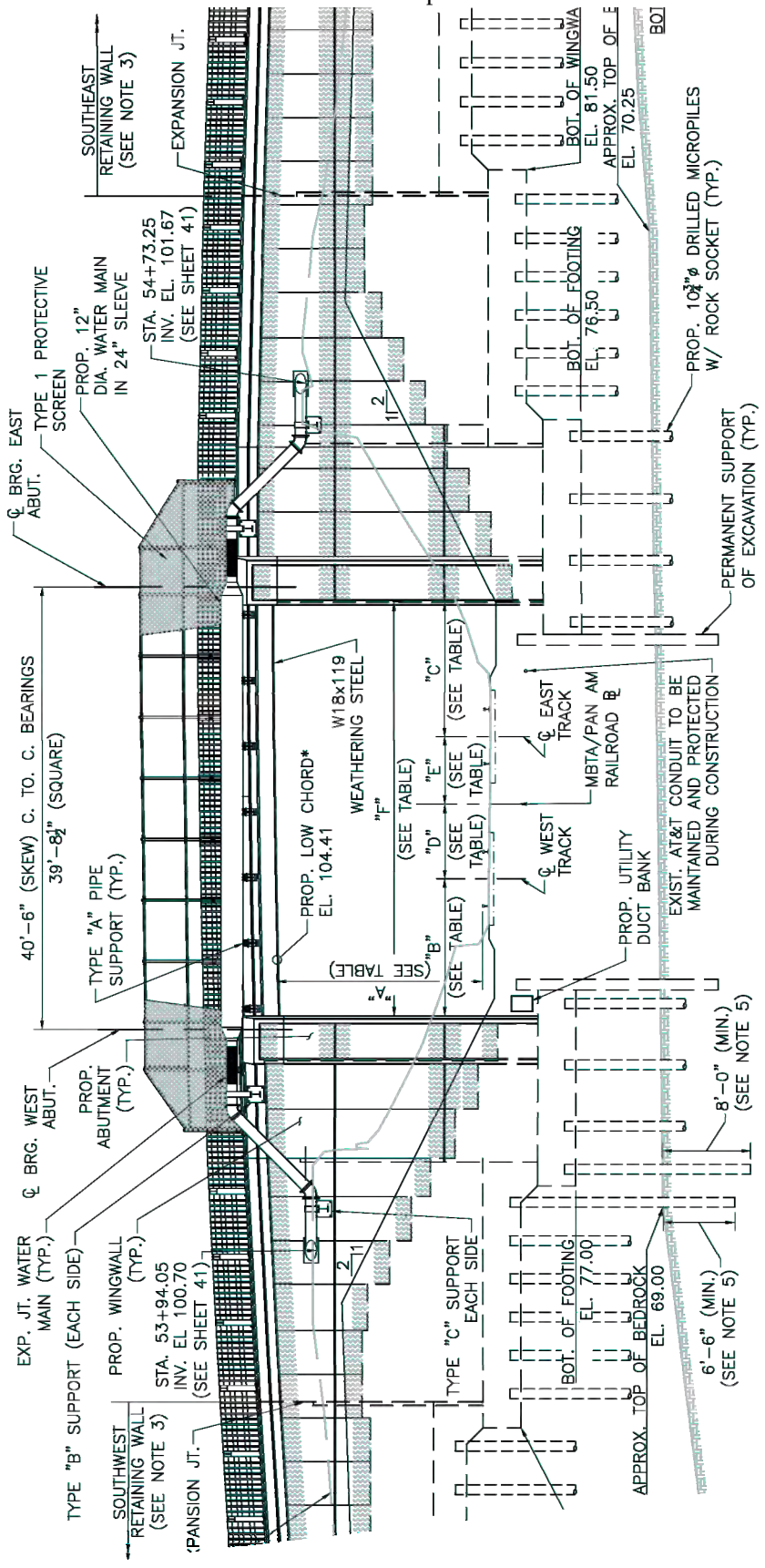
NEWTON, MASS.

Fig. 6



BRIDGE ELEVATION

VERTICAL AND HORIZONTAL RR CLEARANCES				
DIMENSION	EXISTING		PROPOSED	
A	17'-0"±		MIN. 18'-6"	
	SKEWED	SQUARE	SKEWED	SQUARE
B	5'-11"±	5'-10"±	12'-3" MIN.	12'-0" MIN.
C	7'-1"±	6'-11"±	12'-3" MIN.	12'-0" MIN.
D	6'-10½"±	6'-8½"±	6'-10½"	6'-8½"
E	6'-2½"±	6'-0⅝"±	6'-2½"	6'-0⅝"
F	26'-0¼"	25'-6⅝"	37'-9⅜"	37'-0½"

*LOW CHORD ELEVATION BASED ON 7'-0" ENVELOPE RELATIVE TO CENTERLINE OF TRACK.

massDOT Highway

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

BRIDGE ELEVATION
SCALE: NOT TO SCALE

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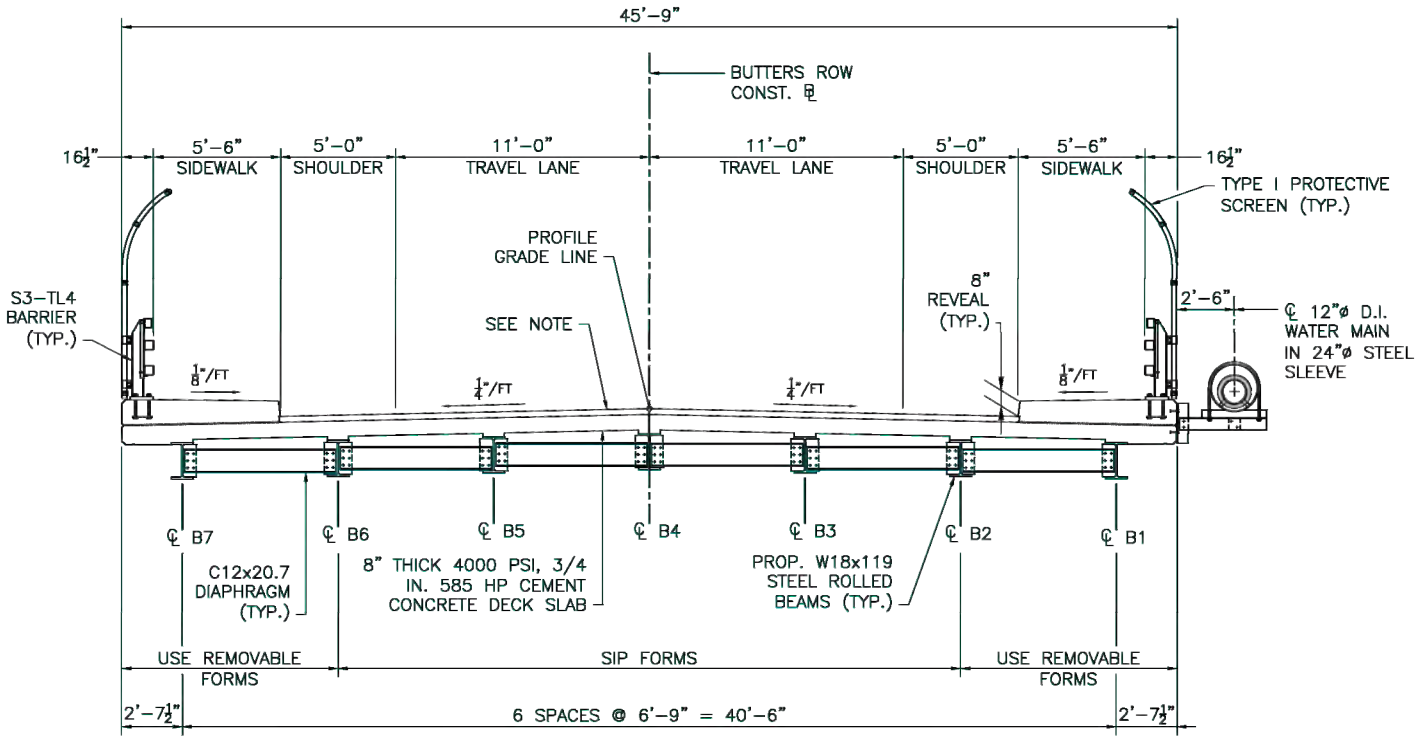
NEWTON, MASS.

Fig. 7

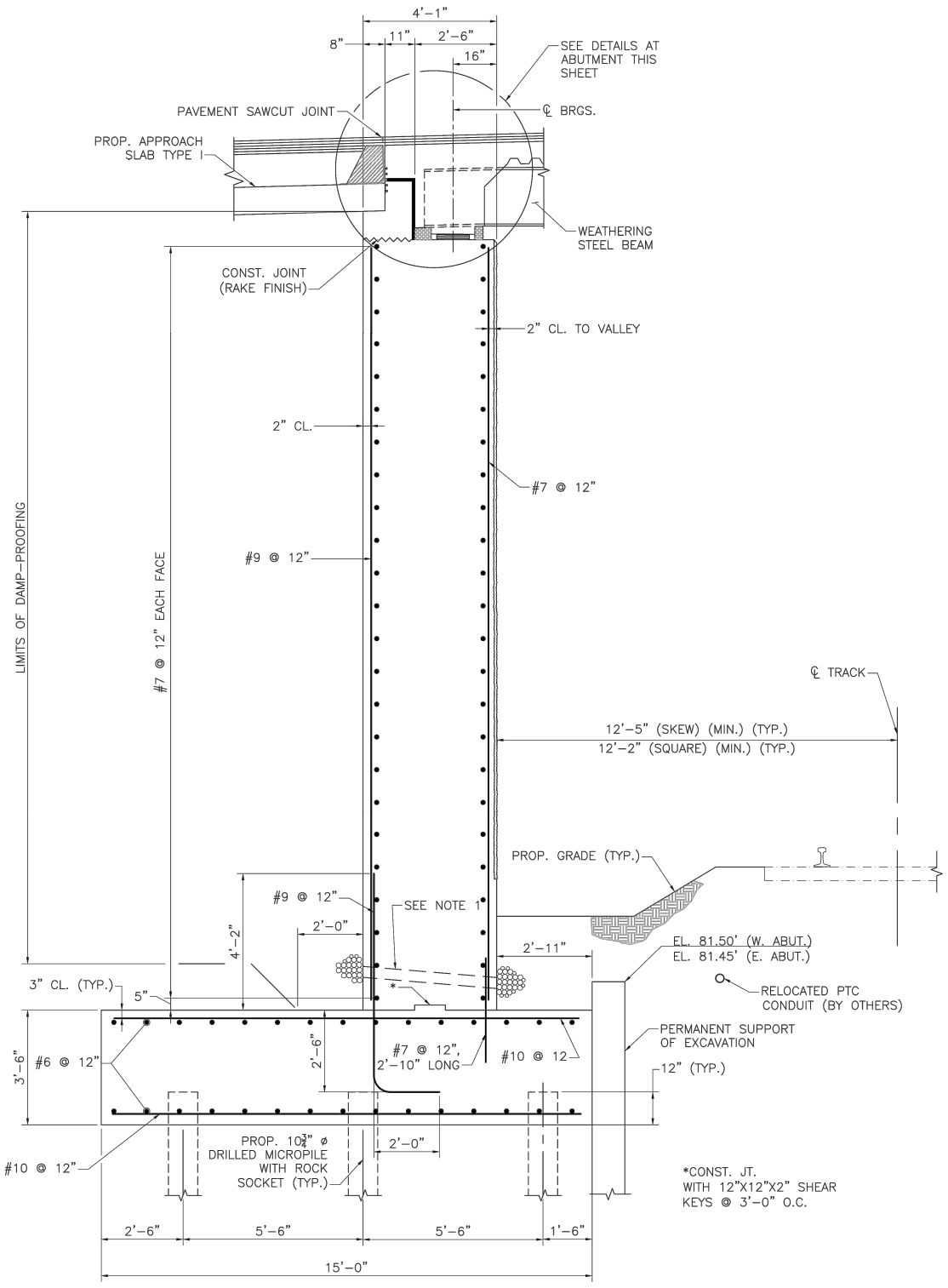


NOTE:
1½" SUPERPAVE BRIDGE SURFACE COURSE – 9.5 – POLYMER (SSC–B–9.5–P) OVER
1½" SUPERPAVE BRIDGE PROTECTIVE COURSE – 9.5 – POLYMER (SPC–B–9.5–P) OVER
SPRAY APPLIED MEMBRANE WATERPROOFING

PROPOSED TRANSVERSE SECTION

SOURCE: FROM GREEN'S PLANS SUBMITTAL.

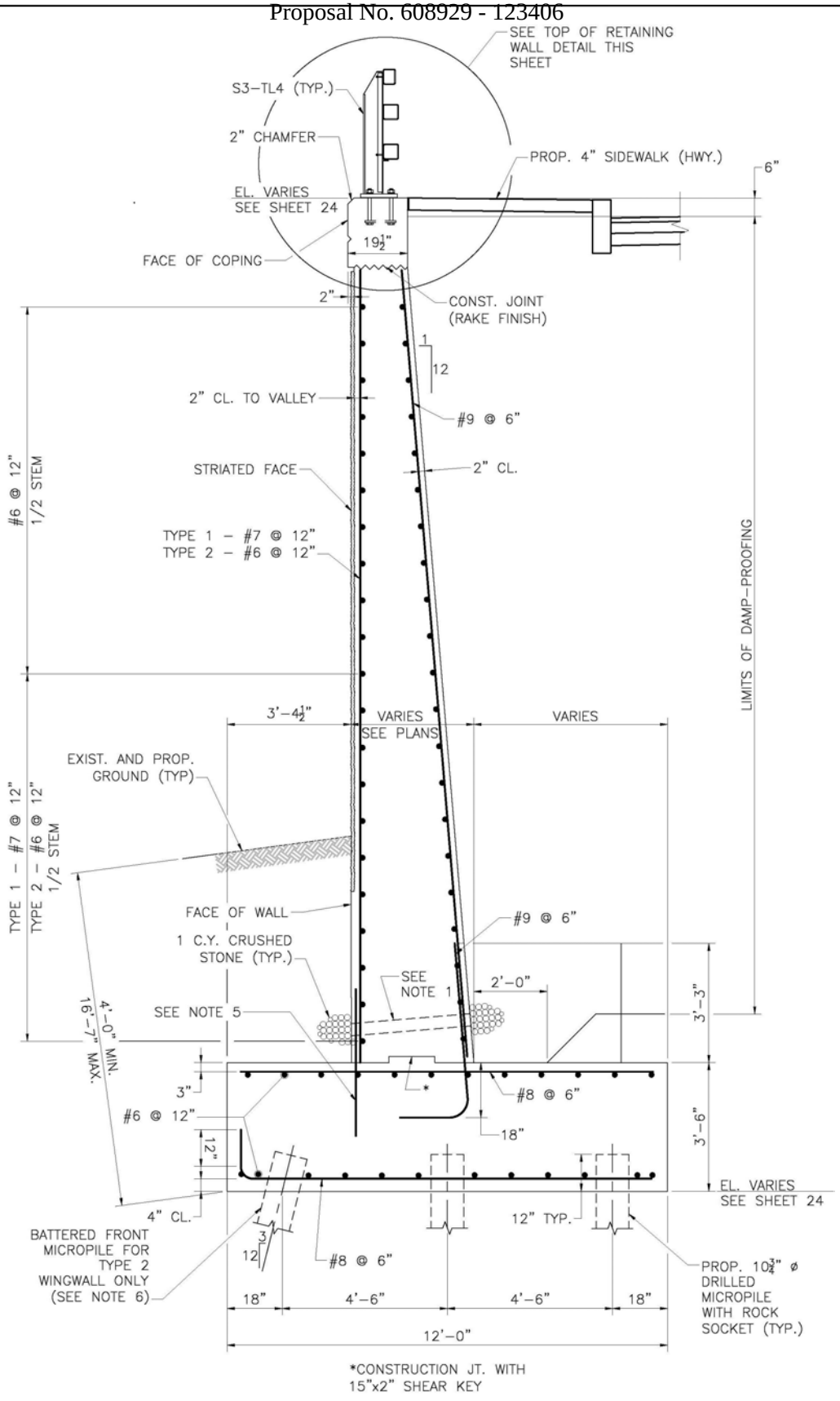
massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. BRIDGE NO. W–38–003 (C99) BUTTERS ROW OVER MBTA/PAN AM RAILROAD WILMINGTON, MASSACHUSETTS	PROPOSED TRANSVERSE SECTION SCALE: NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 8



PROPOSED ABUTMENT SECTION

SOURCE: FROM GREEN'S PLANS SUBMITTAL.

massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. BRIDGE NO. W–38–003 (C99) BUTTERS ROW OVER MBTA/PAN AM RAILROAD WILMINGTON, MASSACHUSETTS	PROPOSED ABUTMENT SECTION SCALE: NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 9



SOURCE: FROM GREEN'S PLANS SUBMITTAL.

massDOT Highway

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PROPOSED WINGWALL TYPES 1 & 2 SECTION
SCALE: NOT TO SCALE

PREPARED BY
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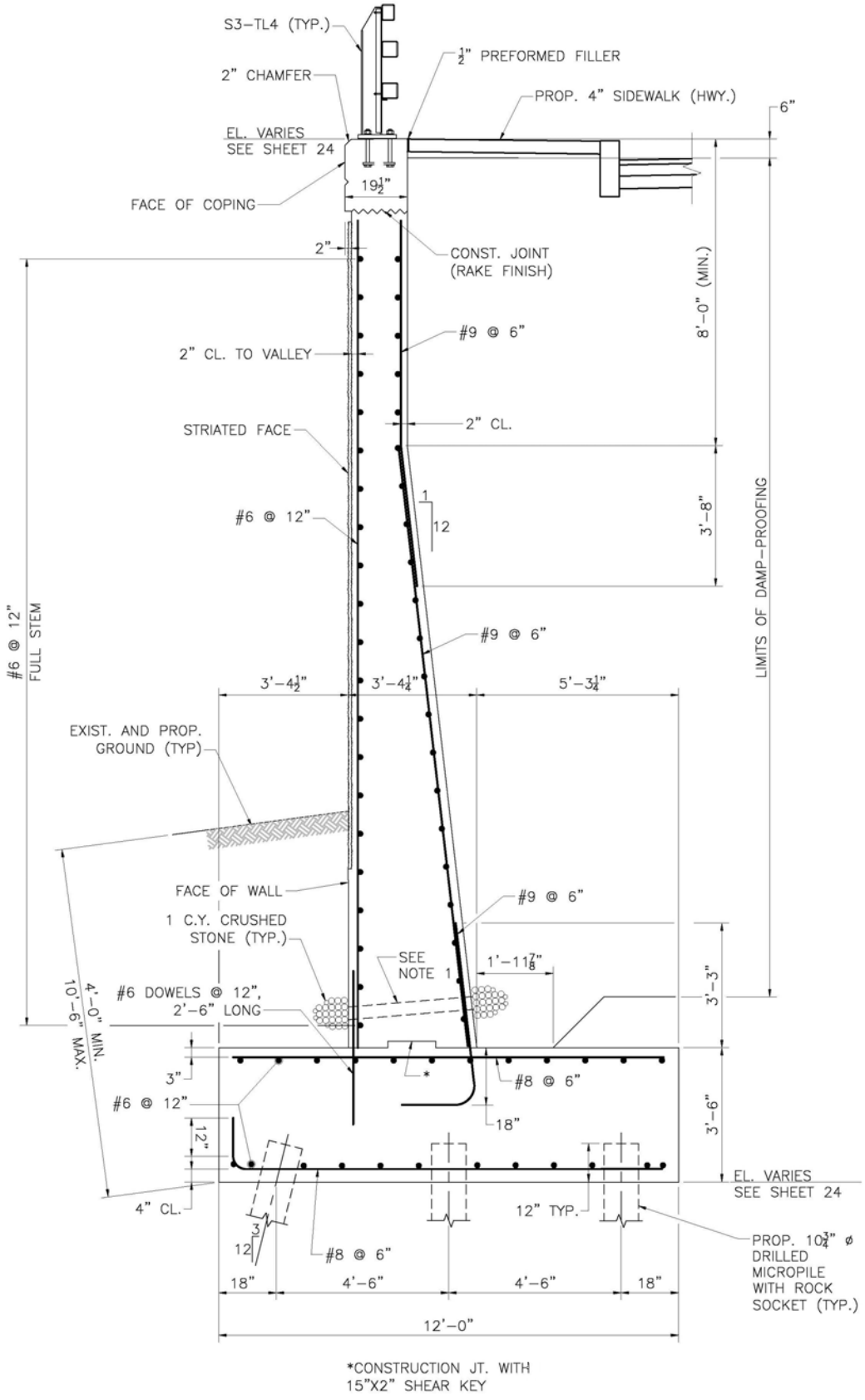
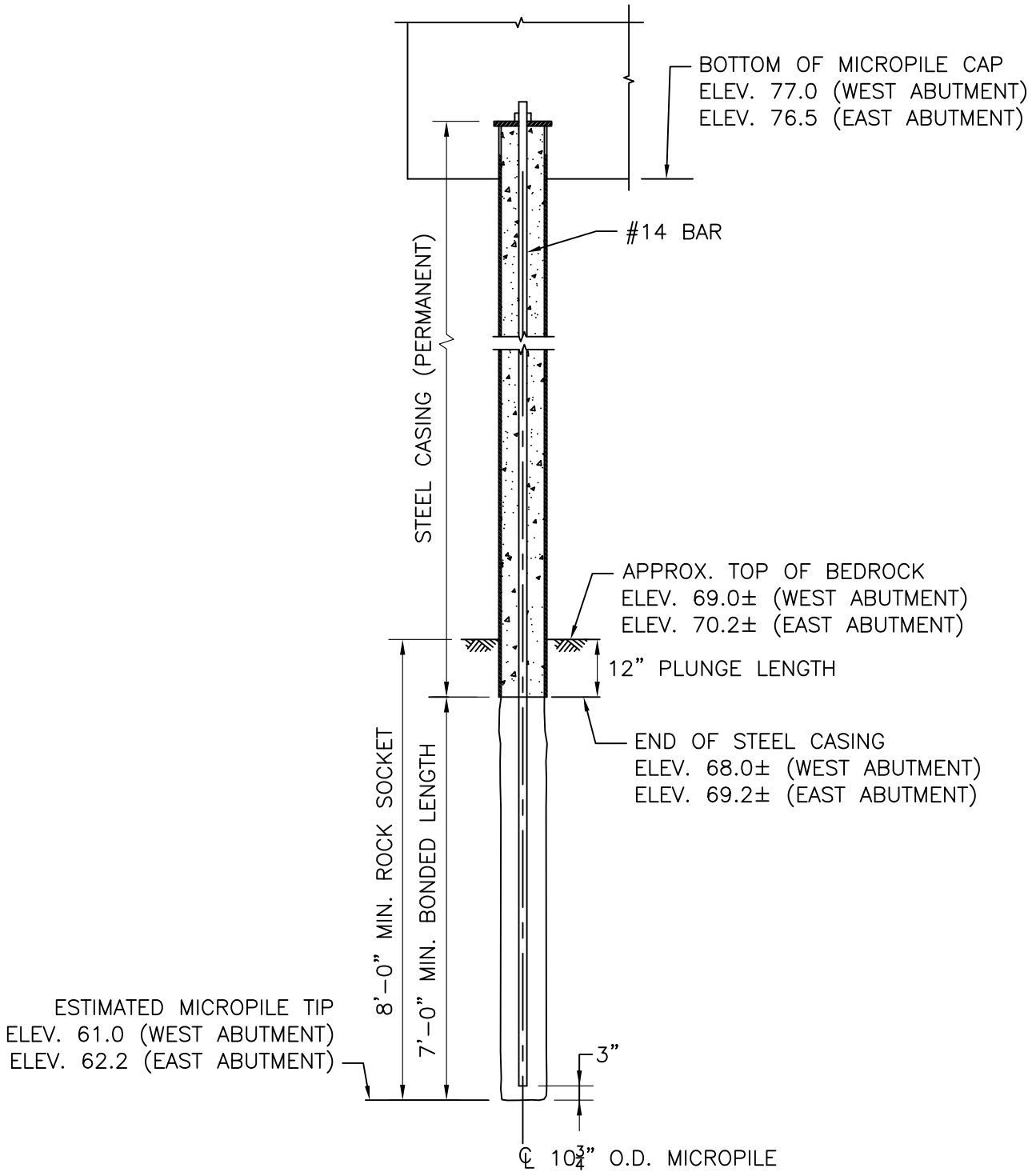
NEWTON, MASS.

Fig. 10

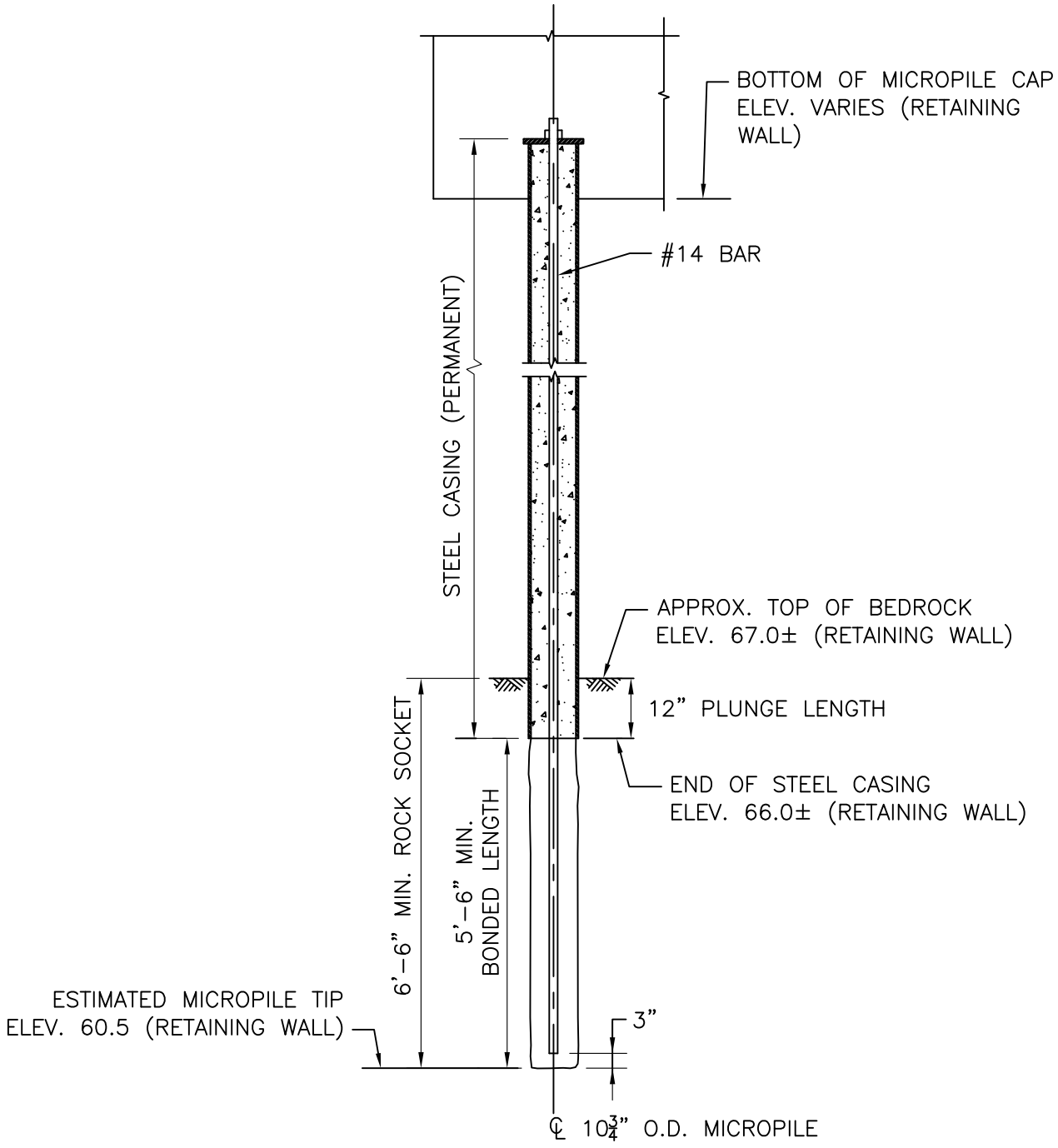


SOURCE: FROM GREEN'S PLANS SUBMITTAL.

massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. BRIDGE NO. W-38-003 (C99) BUTTERS ROW OVER MBTA/PAN AM RAILROAD WILMINGTON, MASSACHUSETTS	PROPOSED WINGWALL TYPE 2A SECTION SCALE: NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 11



massDOT Highway GREEN INTERNATIONAL AFFILIATES, INC. BRIDGE NO. W-38-003 (C99) BUTTERS ROW OVER MBTA/PAN AM RAILROAD WILMINGTON, MASSACHUSETTS	PROPOSED ABUTMENT & WINGWALL TYPE 1 MICROPILE SCALE: NOT TO SCALE PREPARED BY LAMSON ENGINEERING CORP. NEWTON, MASS.	Fig. 12



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GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PROPOSED WINGWALL TYPE 2 & 2A MICROPILE
SCALE: NOT TO SCALE

PREPARED BY
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NEWTON, MASS.

Fig. 13

GREEN INTERNATIONAL AFFILIATES, INC.
BRIDGE NO. W-38-003 (C99)
BUTTERS ROW OVER MBTA/PAN AM RAILROAD
WILMINGTON, MASSACHUSETTS

PREPARED BY
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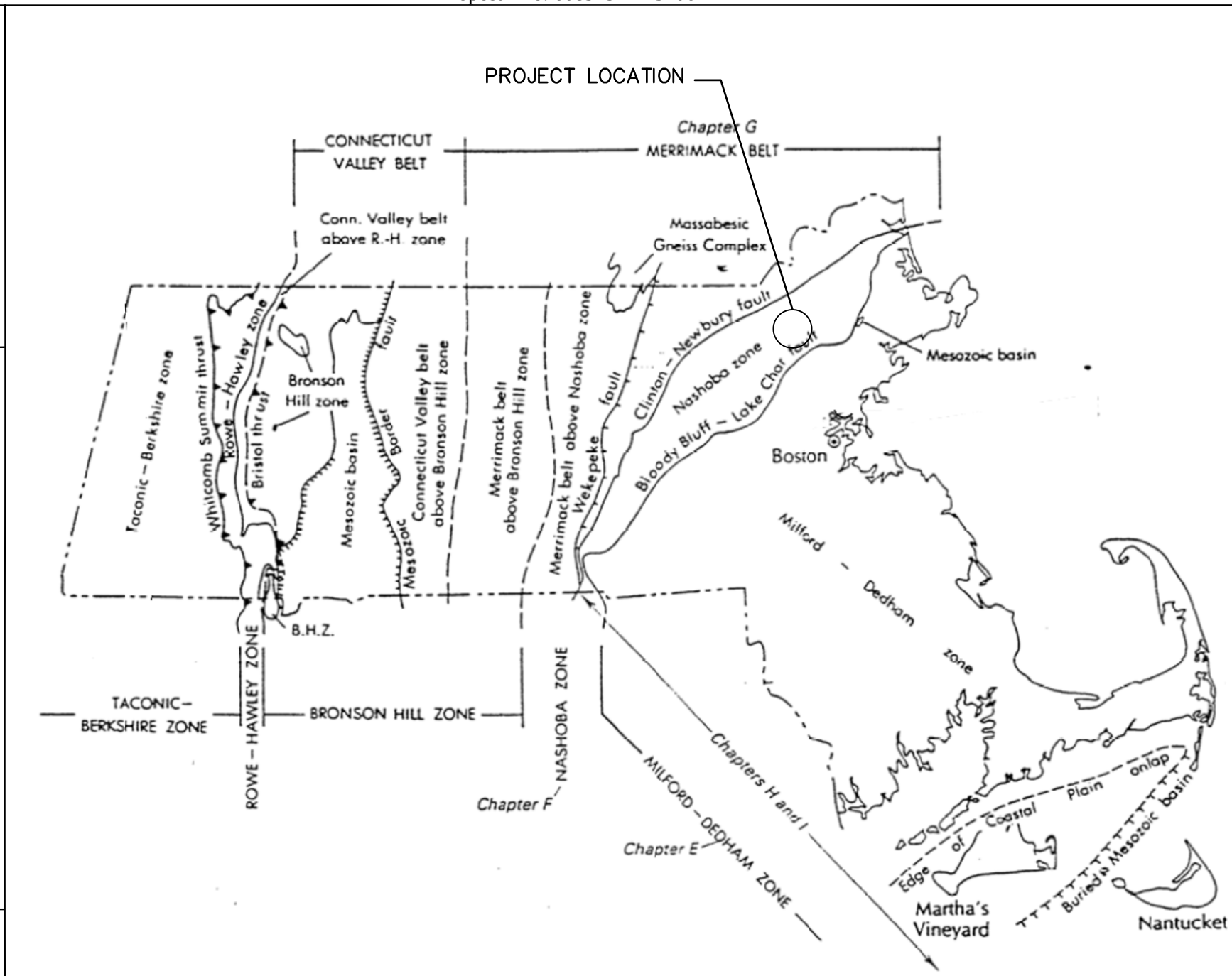
NEWTON, MASS.

MASSACHUSETTS GEOLOGICAL MAP

SCALE: NOT TO SCALE

Fig. 14



APPENDIX 1

2021 Subsurface Exploration Results

(23 sheets)

1. For 2021 boring locations, see Figure 2, '2021 As-Drilled Boring Location Plan'.
2. There are 9 sheets for Borings BB-1, BB-2, BB-3, BB-4, and BB-5
3. There elevations shown on the attached 2021 logs are based on 1988 NAVD datum.
4. Soil Sample recovery photos for BB-1 to BB-5 are included in this Appendix.
5. Bedrock core recovery photos for BB-1, BB-2B, and BB-3 are included in this Appendix.
6. There are 3 sheets for Rock Core Testing Result. Bedrock core sample taken for testing is obtained from Boring BB-2B Elev. 69.5 to Elev. 68.5 (Depth 32' to 33').

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Boring No. BB-1 | Page 1/2

Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: W-38-003 (2NV)	Project File No.: 608929	Contract No.: -
Location: Butters Row over MBTA/PAN AM Railroad		Date & Time Started: 1/12/21 10:30 a.m.	Total Hours:
Groundwater Depth (Feet): 12.6' Date & Time: 1/13/21 1:00 p.m.		Date & Time Completed: 1/13/21 1:30 p.m.	9.5
Coordinates: N 3,021,503 E 746,507	Ground Elevation (Feet): 101.5'	Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors	*Driller's Name: Brett Raiche	*Helper's Name: Brian Steen	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt 3.5"	
S-1	1' - 3'	9 24 18 15	9"	Dry, dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-2	4' - 6'	6 12 10 13	6"	Dry, medium dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	
S-3	9' - 9'2"	120/2"	0"	No Recovery	9'2"
				Boulder	15'4"
S-4	15'6" - 17'6"	4 3 13 13	15"	Wet, medium dense, brown, FINE TO COARSE SAND, trace fine gravel.	
S-5	19' - 21'	11 13 17 15	13"	Wet, medium dense, brown, FINE SAND.	24'
S-6	24' - 26'	7 10 12 16	14"	Wet, medium dense, gray, FINE SAND, some inorganic silt.	
S-7	30' - 32'	20 15 9 12	7"	Wet, medium dense, gray, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, some inorganic silt.	
				Top of Bedrock @ 32'6"	32'6"
				Rollerbit to 34' and begin coring.	
C-1	34' - 39'	4 4 5 5 4	60"	Fresh, hard, gray, DIORITE. Percent Recovery = 100% RQD = 60"/60" = 100%	

Moving Massachusetts Forward massDOT Highway

Boring Log

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Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 603028 - 2566

Boring No. BB-1 | Page 2/2

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
C-2	39' - 44'	4 4 4 5 4	60"	Fresh, hard, gray, DIORITE. Percent Recovery = 100% RQD = 54"/60" = 90%	
					44'
				Bottom of Exploration @ 44'	

Notes:

* Mark D'Ambrosio and Cody Richards took over on 1/13/21 using Truck rig - GT8.

Arrow-Board: -
Signs: 2
Cones: 6

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
		Hard	Over 30

N=Sum of Second and Third 6" Blow Counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: Soil Scout

Hammer Weight: 140 lbs Fall: 30"
Casing Types: HW NW
Size: 4" 3"
Depth: 9' 34'

Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight:
Safety Hammer Weight: 140 lbs
Donut Hammer Weight: Fall: 30"

Core Barrel Type: NX Size: 2.155"

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 608929 - 2 Rev

Boring No. BB-2 | Page 1/1

Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: W-38-003 (2NV)	Project File No.: 608929	Contract No.: -
Location: Butters Row over MBTA/PAN AM Railroad		Date & Time Started: 1/13/21 2:00 p.m.	Total Hours:
Groundwater Depth (Feet): - Date & Time: -		Date & Time Completed: 1/13/21 2:30 p.m.	0.5
Coordinates: N 3,021,507 E 746,558	Ground Elevation (Feet): 102.0'	Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors	Driller's Name: Mark D'Ambrosio	Helper's Name: Cody Richards	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt 3.5"	
				Dry, brown, SAND AND GRAVEL.	1'4"
				Concrete 1'6"	
				Bottom of Exploration @ 1'6"	
				- Terminated at 1'6" deep due to concrete obstruction. Moved 4'± North and created BB-2A.	

Notes:

Arrow-Board: -
Signs: 2
Cones: 6

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: Truck GT-8

Hammer Weight: - Fall: -
Casing Types: -
Size: -
Depth: -

Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight:
Safety Hammer Weight: 140 lbs
Donut Hammer Weight: Fall: 30"

Core Barrel Type: - Size: -

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 608929 - 2 Rev

Boring No. BB-2A | Page 1/1

Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: W-38-003 (2NV)	Project File No.: 608929	Contract No.: -
Location: Butters Row over MBTA/PAN AM Railroad		Date & Time Started: 1/14/21 8:00 a.m.	Total Hours:
Groundwater Depth (Feet): - Date & Time: -		Date & Time Completed: 1/14/21 9:00 a.m.	1
Coordinates: *N 3,021,511 *E 746,558	Ground Elevation (Feet): *101.7'	Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors	Driller's Name: Mark D'Ambrosio	Helper's Name: Cody Richards	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt 3.5"	1'4"
				Dry, brown, SAND AND GRAVEL.	
				Concrete 1'6"	
				Bottom of Exploration @ 1'6"	
				- Terminated at 1'6" deep due to concrete obstruction. Moved 5'± North and created BB-2B.	

Notes:

* Located 4'± North of As-Drilled BB-2. Coordinates and elevation are estimated.

Arrow-Board: -
Signs: 4
Cones: 6

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
N=Sum of Second and Third 6" Blow Counts		Hard	Over 30

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: Truck GT-8

Hammer Weight: - Fall: -
Casing Types: -
Size: -
Depth: -

Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight:
Safety Hammer Weight: 140 lbs
Donut Hammer Weight: Fall: 30"

Core Barrel Type: - Size: -

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 608929 - 2R46

Boring No. BB-2B | Page 1/2

Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: W-38-003 (2NV)	Project File No.: 608929	Contract No.: -
Location: Butters Row over MBTA/PAN AM Railroad		Date & Time Started: 1/14/21 9:00 a.m.	Total Hours:
Groundwater Depth (Feet): 15' Date & Time: 1/15/21 10:00 a.m.		Date & Time Completed: 1/15/21 10:30 a.m.	8
Coordinates: *N 3,021,516 *E 746,558	Ground Elevation (Feet): *101.5'	Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors	Driller's Name: Mark D'Ambrosio	Helper's Name: Cody Richards	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Asphalt 3.5"	1'4"
				Dry, brown, SAND AND GRAVEL.	
				Concrete	3'
S-1	4' - 6'	7 10 9 6	11"	Dry, medium dense, dark gray, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	9'
S-2	10' - 12'	5 5 6 8	4"	Dry, medium dense, brown, FINE TO COARSE SAND, trace fine gravel.	13'
				Black, ORGANICS from wash.	14'
S-3	15' - 17'	9 40 57 56	15"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, some inorganic silt.	
S-4	20' - 21'4"	42 39 100/2"	9"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, some inorganic silt.	21'4"
				Boulders / Cobbles	24'10"
S-5	25' - 27'	28 14 23 20	6"	Wet, dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	28'10"
				Cobbles 29'5"	
S-6	30' - 31'3"	25 36 85/3"	5"	Wet, very dense, brown, FINE TO COARSE SAND AND FINE TO COARSE GRAVEL, trace inorganic silt.	31'3"
				Top of Bedrock @ 31'3"	
				Rollerbit to 32' and begin coring.	
C-1	32' - 37'	3 3 4 5 5	50"	Fresh, hard, gray, GRANODIORITE. Percent Recovery = 83% RQD = 50"/60" = 83%	

Moving Massachusetts Forward MassDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION
437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 603028 - 2566

Boring No. BB-2B | Page 2/2

Scale: 1" = 5'

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
C-2	37' - 42'	4 5 5 5 6	58"	Fresh, hard, gray, GRANITE GNEISS. Percent Recovery = 97% RQD = 50"/60" = 83%	42'
				Bottom of Exploration @ 42'	

Notes:

* Located 5'± North of As-Drilled BB-2A. Coordinates and elevation are estimated.

Arrow-Board: -
Signs: 4
Cones: 6

Protective Device Stand: - Box: -
Well Depth: - Solid Pipe: -
Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
		Hard	Over 30

N=Sum of Second and Third 6" Blow Counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: Truck - GT8

Hammer Weight: 300 lbs Fall: 24"
Casing Types: HW NW
Size: 4" 3"
Depth: 21' 32'

Sampler Type: S/S Size: 1 3/8" ID
Automatic Hammer Weight:
Safety Hammer Weight: 140 lbs
Donut Hammer Weight: Fall: 30"

Core Barrel Type: NX Size: 2.155"

Moving Massachusetts Forward massDOT Highway

Boring Log

LAMSON ENGINEERING CORPORATION

437 Cherry Street, #109, Newton, Massachusetts 02465
Phone: (617) 558-0101 E-Mail: Lamsoneng@msn.com

Project No. 608929 - 2 Rev.

Boring No. BB-3 | Page 1/1

Scale: 1" = 5'

City/Town: Wilmington	Bridge No.: W-38-003 (2NV)	Project File No.: 608929	Contract No.: -
Location: Butters Row over MBTA/PAN AM Railroad		Date & Time Started: 1/11/21 7:00 a.m.	Total Hours:
Groundwater Depth (Feet): 4.0' Date & Time: 1/11/21 1:00 p.m.		Date & Time Completed: 1/11/21 1:30 p.m.	6.5
Coordinates: *N 3,021,527 *E 746,470	Ground Elevation (Feet): *87.2'	Inspector's Name: Weijie Dong	
Drilling Company: New England Boring Contractors	Driller's Name: Brett Raiche	Helper's Name: Brian Steen	

Sample Number	Depth Range (Feet)	Blow Counts per 6 Inches / Coring Times Minute Per Foot	Recovery (inches)	Field Description	Strata Changes
				Topsoil 4"	
S-1	0' - 2'	6 9 5 8	10"	Dry, medium dense, black, FINE TO COARSE SAND, some organic silt, trace fine gravel.	
S-2	4' - 6'	4 4 4 8	0"	No Recovery (Loose materials, black, Sand & Organic Silt from Wash)	8'2"
				WOOD	9'6"
S-3	10' - 12'	4 3 4 7	4"	Wet, loose, brown, FINE TO COARSE SAND, trace fine gravel.	
S-4	14' - 16'	2 12 6 5	10"	Wet, medium dense, brown, FINE TO COARSE SAND, trace fine gravel.	
S-5	19' - 20'3"	11 17 80/3"	8"	Wet, very dense, brown, FINE TO COARSE SAND, some fine to coarse gravel, trace inorganic silt.	20'3"
				Top of Bedrock @ 20'3"	
				Rollerbit to 20'6" and begin coring.	
C-1	20'6" - 25'6"	5 6 6 5 6	60"	Fresh, hard, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 100% RQD = 50"/60" = 83%	
C-2	25'6" - 30'6"	6 5 5 6 6	60"	Fresh, hard, slightly fractured, gray, GRANITE GNEISS. Percent Recovery = 100% RQD = 53"/60" = 88%	30'6"
				Bottom of Exploration @ 30'6"	

Notes:

* Moved 12'± West due to slope. Coordinates and elevation are estimated.

Arrow-Board: - Signs: - Cones: -

Protective Device Stand: - Box: - Well Depth: - Solid Pipe: - Stick Up Pipe: - Screen Pipe: -

Penetration Resistance (N) Guide:

Cohesionless Soils (Sands, Gravels)		Cohesive Soils (Silts, Clays)	
Relative Density	Penetration Resistance	Consistency	Penetration Resistance
Very Loose	0 - 4	Very Soft	0 - 2
Loose	4 - 10	Soft	2 - 4
Medium Dense	10 - 30	Medium Stiff	4 - 8
Dense	30 - 50	Stiff	8 - 15
Very Dense	Over 50	Very Stiff	15 - 30
		Hard	Over 30

N=Sum of Second and Third 6" Blow Counts

Terms Used for Second Entry of Descriptions: and = 40-50%, some = 10-40%, trace = 10% or less

Type of Drill Rig: Soil Scout

Hammer Weight: 140 lbs Fall: 30"

Casing Types: HW NW

Size: 4" 3"

Depth: 9' 20'

Sampler Type: S/S Size: 1 3/8" ID

Automatic Hammer Weight:

Safety Hammer Weight: 140 lbs

Donut Hammer Weight: Fall: 30"

Core Barrel Type: NX Size: 2.155"